

THE WORLD OF CHEMISTRY

Program #26

FUTURES

Producer Robert Kaper

Air Script: October 31, 1988

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Annenberg/CPB Project Logo and Music

Funder Credits

MONTAGE: Chemical
models, chemists working
in labs, cells under
microscopes, chemical plants

MUSIC

SUPER: FUTURES

THE WORLD OF CHEMISTRY OPEN: Montage, Music, Logo

RH in office

DR. ROALD HOFFMANN (SYNC):
What is ahead in the future for
chemistry and for the society that is so
affected by chemistry? Much
excitement, deeper understanding, new
molecules that no one has yet thought of.
But one thing is not going to change.
This science is done by people, people
such as yourselves. (cont.)

ROALD HOFFMANN cont:

Oh, they may have fancy titles, Chief Executive Officer of this company, head scientist, professor, Nobel Laureate, but behind these titles are just people, people obsessed by curiosity. Chemistry has been a democratizing force. It has brought a wider range of products to more people than could ever afford them before. Chemists care about their science and about their society. And so, in this program, we brought some of those people together. They have some intriguing and dramatic opinions. And because I'm one of them, just a chemist, I'm going to join my friends in this half hour. We will look at the future as best we can. What lies in the years ahead is certain to exceed our vision.

INTERVIEW: Dr. Jacqueline
Barton, Columbia University

DR. JACQUELINE BARTON (SYNC):

Where I think chemistry is going is outwards, in different directions, outwards towards the areas of biology, and that's -- those are the sorts of things that I'm involved in. It's outwards towards physics, towards the areas of engineering, towards the construction of different kinds of materials, and also towards the construction of different kinds of biopolymers.

INTERVIEW: Dr. Howard
Schneiderman, Chief Scientist,
Monsanto

DR. HOWARD SCHNEIDERMAN
(SYNC):

So if I had a career plan that I wanted to be part of 21st Century shock troops that are attacking the major diseases of plants, of animals, and so on, I want to clean up toxic waste, I want to clean up the ocean, I want to get rid of AIDS, I want to get rid of the great -- I want to get rid of malaria, schistosomiasis, and so on. That's gonna be accomplished by manipulating molecules. The chemists will be in the middle of it.

Shots of the STM, images
of the atom

NARRATOR (MUSIC under):

As they broaden their horizons and ours, chemists are linked to new instruments and techniques. For example, the latest electron microscopes image objects in ways impossible only a few years ago. Dr. Howard Schneiderman, Chief Scientist, Monsanto.

INTERVIEW: Dr. Howard
Schneiderman cont.

SUPER: Howard Schneiderman,
Monsanto

DR. HOWARD SCHNEIDERMAN
(SYNC):

We have gotten to a point where we can
see a molecule. We can see a molecule.
With a tunneling electron microscope,
with a variety of techniques we can see
molecules.

Shots of lasers

NARRATOR (NAT SOUND under):
Chemists can now probe the interior of
molecules with lasers, and a hydrogen
fluoride chemical laser may have future
applications that its inventor never fully
intended. Dr. George Pimentel.

INTERVIEW: Dr. George
Pimentel, University of
California, Berkeley

SUPER: George Pimentel,
U.C. Berkeley

DR. GEORGE PIMENTEL (SYNC):
It turned out to be a very effective and
powerful laser, so powerful, in fact, that
it was considered as a possible weapon,
that is to say, a chemical reaction which
could produce a light ray, a laser light
ray, with sufficient intensity, sufficient
power, to possibly do some damage.

Scanning the brain

NARRATOR (NAT SOUND under):
And there are scanners in medical diagnosis using radioactive isotopes. Emissions maps the functions of different organs, including the brain in action. Another application of this technique is in testing new drugs. Dr. Michael Welch.

INTERVIEW: Dr. Michael Welch, Washington University

SUPER: Michael Welch, Washington University

DR. MICHAEL WELCH (SYNC):
If drug companies label the new drug with a positron-emitting radio nuclide, administer it to patients or normals, they can find out the mode of action, they can find out how much concentrates in a particular part of the body, they can find out how long it stays in that part of the body. They can find out if it goes to a part of the body they don't expect it to go to.

Computer graphics

NARRATOR (NAT SOUND under):
And there are computers in chemistry. Computer graphics illuminate molecular architecture. They enhance innovation in design. Dr. Bertram Fraser-Reid.

INTERVIEW: Dr. Bertram
Fraser-Reid, Duke University

SUPER: Bertram Fraser-Reid,
Duke University

DR. BERTRAM FRASER-REID
(SYNC):

Imagine that you want to bring two
bodies together, to fuse them together.
Now, what is the best way to do that? Is
it better that they come together in this
way, or in this way? What forces
govern this choice versus this choice? A
computer can tell you that because you
can probably plot in the various things
that favor coming together this way
versus some things that favor coming
together in this way.

Microscopic images, lasers,
scanners, computer graphics,
material being stretched

NARRATOR (MUSIC and NAT
SOUND under):

Super microscopes, lasers, scanners,
computers and more, new technologies
linked to chemistry. Chemistry is
spreading outward, a vigorous new
partner in other domains of science, like
material science. Dr. Frank DiSalvo.

INTERVIEW: Dr. Frank
DiSalvo, Cornell University

SUPER: Frank DiSalvo, Cornell
University

DR. FRANK DI SALVO (SYNC):
We have to both make materials and look at their properties, which is the overlap between chemistry and physics, if you want. In order to do the kinds of things you want to do with a chemist, or as a physicist, you have to have appreciation for what went in to making the solid, or what I can do to the solid to change its properties, for example. So you need to understand both sides of the fence, and that's becoming a larger and larger requirement in the field of solid state chemistry, solid state physics. If you look at physics today, you look at physicists and ask what they are doing, more than half of all physicists are working on materials, and that means that they're working on things that have to be made by chemists or someone, material scientists, making materials, and they're trying to understand why these materials behave the way they behave. And so the overlap between chemistry and physics is already very large.

INTERVIEW: Keith
McKennon, President,
Dow USA

NARRATOR:
Keith McKennon, President, Dow USA.

SUPER: Keith McKennon,
Dow U.S.A.

KEITH MC KENNON (SYNC):
The new kinds of materials that are
being developed have remarkable,
remarkable properties. I mean, they
have thermal properties, and tensile
strength properties that are almost
unbelievable in the context of the
materials we are used to seeing. So, for
very sophisticated kinds of application,
and high speed aircraft are an example
of those, so-called Orient Express, and
projects like that will, I think, find a use
for those kinds of materials. The space
program, as I'm sure people are aware,
has been a major impetus in developing
new materials and developing the whole
field of material science. I believe that's
gonna continue, and that, in the next
century, as I say, we'll see materials that
we can only imagine today.

INTERVIEW: Richard
Heckert, Chairman,
The DuPont Company

NARRATOR:
Richard Heckert, Chairman, the Du Pont
Company.

SUPER: Richard Heckert,
DuPont

RICHARD HECKERT (SYNC):
We've discovered that you can fill
polymer systems, even ceramics, with
high modulus inorganic materials,
carbon fiber, some organic materials
too, things like our Kevlar, or glass
fiber, or inorganic fibers of various
types from different minerals. Some of
these old systems, filled with those
materials, produce remarkable
compositions that will do jobs that we
never thought plastics capable of doing.

Superconducting materials,
periodic table

NARRATOR (NAT SOUND under):
And then there are the superconducting
materials. Their invention shows how a
chart a hundred years old will still have
a great future a hundred years hence.

INTERVIEW: Dr. Frank
DiSalvo cont.

DR. FRANK DI SALVO (SYNC):

Copper oxide superconductors are made by combining copper with oxygen. That bonding is rather covalent, making, in just combining copper and oxygen, a binary compound that's not so interesting. But if I combine them further still with elements from the left-hand side of the periodic table, like lanthanum or strontium, I obtain interesting superconductors. That appears to come from the interplay between the ionic bonds that these materials want to have with oxygen and the covalent bonds that copper wants to have with oxygen. If you were to ask me to summarize on one sheet of paper all the potential things that could happen in chemistry, not only in chemistry, but in all fields of science, physical science that is, and maybe in engineering, the one sheet of paper I'd give you would be the periodic table. That's everything we ever will do in science is summarized here. All the compounds that we'll ever make will come just from combining these elements, these hundred-odd elements on this one sheet of paper.

Periodic table graphic,
computer graphics,
molecular models

NARRATOR (MUSIC and NAT
SOUND under):

The periodic table was a product of
basic research. Tomorrow, as today,
there will be those who seek purely to
acquire new knowledge for its own sake,
with no regard to eventual application.
Much fundamental research in the future
will be done to create new molecules.
Nobel Laureate Roald Hoffmann.

INTERVIEW: Dr. Roald
Hoffmann, Cornell University

SUPER: Roald Hoffmann,
Cornell University

DR. ROALD HOFFMANN (SYNC):
People make molecules for all kinds of
reasons. One of them is that a molecule
is beautiful. That, for instance, is the
case with this fantastic platonic
polyhedron, as it's called, of
dodecahedrane, with 20 carbon atoms in
it, with 12 faces, all pentagons. This
was made not too long ago by a friend
of mine at Ohio State, Leo Paquette.
Now, he made it because it was a goal, a
mountain to be climbed. Many people
had tried, no one had made it, and it's
esthetically pleasing in its symmetry.

INTERVIEW: Dr. Jacqueline
Barton cont.

NARRATOR:
Dr. Jacqueline Barton.

SUPER: Jacqueline Barton,
Columbia University

DR. JACQUELINE BARTON (SYNC):
Now, where I think we're going is into
bigger and, in some respects, more
complicated structures. Those kinds of
complicated structures allow us to
design, in one respect, on a molecular
level, macromolecular assemblies, multi-
atom assemblies that have a particular
material characteristic, as a particular
macroscopic characteristic. And yet
what we're really doing is we're
tailoring, we're designing that material
on a molecular level.

INTERVIEW: Dr. Roald
Hoffmann cont.

DR. ROALD HOFFMANN (SYNC):
We see this gracefully curving triple
helix. Now, this structure has not been
made. What I see is that it's pretty, it's
beautiful. And it also has some
interesting properties. So, in a few
months, we will publish something on
this, and maybe someone will try to
make it then.

Shots of insulin bottles on
assembly line, insulin injection
being drawn

NARRATOR (NAT SOUND under):
Beyond basic research, the synthesis of
new molecules will sometimes have
enormously beneficial applications.
Increasingly, chemistry will enter the
domain of medical science.

INTERVIEW: Dr. Bertram
Fraser-Reid cont.

DR. BERTRAM FRASER-REID
(SYNC):
The sophistication of drugs demands that
we have a better and better
understanding of biology, of
biochemistry, how nature does things,
because there is still so much to learn,
and my goodness, the hardest thing that
takes me years to do, nature does in a
matter of seconds. The secrets there still
have to be unraveled.

Chemist working in lab

NARRATOR:
Unlocking those secrets will assist in the
rational design of drugs.

INTERVIEW: Dr. Michael
Welch cont.

DR. MICHAEL WELCH (SYNC):
Monoclonal antibodies are molecules that are specific, again, to proteins in the body, particularly to, to sites on tumors, that if one can label these antibodies with radioisotopes, one can either see where the tumor is or ultimately, at a large amount of radioactivity, to, in fact, kill the tumor by radiation therapy. This is, in fact, called the "magic bullet" way of killing tumors. If one could get most of the isotope to the tumor, it will perhaps be the ideal way of destroying tumors. Instead of irradiating from the outside of the body, as one does in conventional radiation therapy, one would only radiate the tumor.

INTERVIEW: Richard
Heckert cont.

RICHARD HECKERT (SYNC):
We've come to realize that drugs, obviously, need the right functional groups to attack the target in the body. They also have to fit the space available in attacking that target. The importance of shape, as well as functionality, is one that came to us fairly recently, I guess, not the last year, but within the last decade or so. (cont.)

RICHARD HECKERT cont:

The remarkable thing about the computer is that it will enable us to display in three dimensions, on a video tube, what our complicated molecule looks like, and it enables us to look at the pocket or target where we think a drug might be efficacious, if it were supplied there. And then we can examine different compounds that are potentially useful in the treatment of this disease, or attacking that target, to see if they fit. Now, fit isn't everything, but if it doesn't fit, you probably don't have a decent treatment, a good drug.

INTERVIEW: Dr. Jacqueline Barton cont.

DR. JACQUELINE BARTON (SYNC):

If we can understand the way those proteins work, we can understand the architecture associated with those proteins, then we can do things like, like design better drugs that target and recognize that architecture, and interact with them. And that's, that's really, in some respects, in my mind, the basis of new rational design of pharmaceuticals. That is, in developing any new pharmaceutical agent, what we have to do is either come up with a molecule that either recognizes the molecular architecture of a biopolymer or acts a monkey wrench, if you will, for interfering with the chemical reaction that occurs on that biopolymer.

INTERVIEW: Dr. Howard
Schneiderman cont.

DR. HOWARD SCHNEIDERMAN
(SYNC):

I think that it represents really the cutting edge of modern chemistry, trying to find mimics for peptides, mimics for proteins. No one has developed a very good technique for making a protein pill or a peptide pill. They get digested, proteins and peptides, in the stomach. It would be great if we could design a molecule that would do the same thing as insulin, but you wouldn't have to inject it, you could take it as a pill. People haven't found that molecule.

Cell research, microscopic
close ups

NARRATOR (MUSIC under):

Chemistry may have an even greater effect on medical science and the host of other disciplines there is a revolution in biotechnology, genetic engineering.

INTERVIEW: Dr. Jacqueline
Barton cont.

DR. JACQUELINE BARTON (SYNC):
In some respects, you don't have to think about recombinant DNA technology, as Woody Allen's world in "Sleeper," with oversized bananas and tomatos. That's not what recombinant DNA technology is all about. What it is all about is our learning how to manipulate and change macromolecular structure and, in so doing, learn an awful lot more about that macromolecular structure and the chemistry that nature's been doing all the time.

INTERVIEW: Richard
Heckert cont.

RICHARD HECKERT (SYNC):
Biotechnology is of interest to us because it is an extension of good, plain old organic chemistry, a very complicated extension of it. I think at this time it's particularly intriguing because we are beginning to understand life processes at the molecular level. We really know what's going on, atom by atom, molecule by molecule. And at that point the organic chemist has a perfect right to be a player on the team.

INTERVIEW: Dr. Howard
Schneiderman cont.

DR. HOWARD SCHNEIDERMAN
(SYNC):

One of the really interesting questions is, what is the relationship between genetic engineering and chemistry, and I would argue that it's a very intimate relationship. It's manipulating molecules.

INTERVIEW: Dr. George
Pimentel cont.

DR. GEORGE PIMENTEL (SYNC):
Chemists have a very important role to play in that particular area. That includes developments, using recombinant techniques, in the medical area. For example, hereditary diseases. It's going to be possible to understand which part of the gene is the part that's causing the problem, and do repair work on it. And perhaps thereby conquer the disease. Chemists will play a role in understanding just exactly what molecules are involved there.

INTERVIEW: Richard
Heckert cont.

RICHARD HECKERT (SYNC):

In our early work with Interleukin 2, which we thought had potential promise as a cancer treatment, or at least as a pharmaceutical for related diseases, we were trying to isolate significant quantities of this material so that we could test it. It took us six months to isolate 10 milligrams from the conventional sources. Today, using recombinant DNA techniques, we can make that much in an afternoon, at one-thousandth of the total cost of the old process. So clearly, this is a very powerful tool.

Cells dividing under
microscope

NARRATOR:

Biotechnology holds out the promise of engineering new molecules into cells of plants as well as of people.

INTERVIEW: Keith
McKennon cont.

KEITH MC KENNON (SYNC):

Among the specialty chemical areas that many of us think have a lot of promise are agricultural chemicals. Again, the world population continues to increase. There are many mouths to feed, will be many more. (cont.)

KEITH MC KENNON cont:

Efficiency and effectiveness in agricultural production is something the whole world is trying to achieve. Agricultural chemical products I think will play a big role in doing it, both products as we think of them today and the new families of bioproducts which, I believe, will be part of the agricultural business of tomorrow.

INTERVIEW: Dr. George Pimentel cont.

DR. GEORGE PIMENTEL (SYNC):

One can see the potentiality for deliberate engineering of the gene that determines the characteristics of the crop, whatever it be, whether it be a food crop and you wish to enhance the amount of growth, or perhaps a food crop that's susceptible to a particular insect pest, or frost damage, or whatever, one has at least the potentiality of reaching into the genes that are involved in the reproduction of that particular plant, and engineering it to provide it protection or enhancement, whatever one wishes. That will involve some very sophisticated chemistry, biochemistry, and molecular biology.

INTERVIEW: Dr. Howard
Schneiderman cont.

DR. HOWARD SCHNEIDERMAN
(SYNC):

We can produce plants which are resistant to diseases for which there is no known chemical that you can use to give those plants resistance. What are such diseases? Viral diseases, viruses. There is nothing you can spray on a crop that will eliminate viruses. But we can genetically engineer tomatoes, and a variety of other crops, so that they are resistant to not just one virus that normally attacks tomatoes, a tomato mosaic virus. We can make those plants resistant to a whole string of viruses, a whole group of viruses. I think that, within the next five years, there will be commercially, in the marketplace, a whole series of crops that are resistant to viral attack.

Greenhouse shots, lab work,
plastic bottles coming off
assembly line

NARRATOR (MUSIC and NAT
SOUND under):

Agricultural products, drugs,
superconductors, structural materials,
expanding avenues for 21st Century
chemistry. But what of the polymers
and plastics we so take for granted
today?

INTERVIEW: Richard
Heckert cont.

RICHARD HECKERT (SYNC):

I suspect we'll be still making ethylene and propylene and polyvinylchloride and all the traditional materials. The businesses that Du Pont is in today, I expect, at least all the good ones, I expect us to be in at the year 2000 and the year 2010.

Chemical reactions, laser disk,
hazardous waste removal

NARRATOR (NAT SOUND under):

So chemists and the chemical industry will continue doing what they've always done, designing and producing new molecules that enrich the lives of us all. But, at the same time, they are assuming new responsibilities.

INTERVIEW: Richard
Heckert cont.

RICHARD HECKERT (SYNC):

One of the most important challenges that the industry faces is to make its products for society without in any way degrading the environment. We have made some mistakes in the past. Most of those mistakes were unintentional, they were simply based on a lack of understanding. (cont.)

RICHARD HECKERT cont:

As we began to fully understand how persistent these by-products, even some products were in the environment, and recognized that some of them, at least, were probably undesirable and should not be there, we began a really a very broad effort to correct this problem. Our products are now being designed to be environmentally acceptable. Our waste streams are being minimized in every conceivable way. And this is a benefit to cost as well as to the environment. We are looking for new ways to recover small amounts of contaminants from drinking water and other parts of the environment that need cleaning up. In the long run, chemistry was gonna tidy up its own nest, and some day we'll win back that approval that we so much desire from the general public.

INTERVIEW: Dr. George Pimentel cont.

DR. GEORGE PIMENTEL (SYNC):

All of my colleagues in chemistry, my colleagues in biochemistry, molecular biology, they must devote more of their energy and learn to communicate with the public, not just the government, certainly including the government, but the public at large. And this is something that we have been reluctant to do. (cont.)

DR. GEORGE PIMENTEL cont:

Far too few of us have actually been willing to come out of the laboratory and take on this very difficult task. But we must do it, not in the interest of chemistry, but in the interest of society.

Chemist working in lab

NARRATOR (NAT SOUND under):

Chemists and chemistry, then, will play new roles in the decades ahead. The people who do the science and the people who direct the industry are confident in their reach.

INTERVIEW: Richard Heckert cont.

RICHARD HECKERT (SYNC):

Chemists are involved in everything. There is no limit. And that's finally recognized and everybody's having fun doing things they used to think were out of bounds.

INTERVIEW: Dr. Frank DiSalvo cont.

DR. FRANK DI SALVO (SYNC):

The number of compounds that could be made potentially out of this are practically countless. We now know of maybe 10 million compounds, but with only perhaps five elements, thinking of the ways we could combine them, we could potentially make 10 billion compounds. (cont.)

DR. FRANK DI SALVO cont:

So if we were to combine many, many, many elements from the periodic table, the number becomes absolutely enormous.

INTERVIEW: Dr. Roald Hoffmann cont.

DR. ROALD HOFFMANN (SYNC):

Look at what nature has done with the tetrahedral carbon atom. It's built up all of these molecules in life. There is an infinity of molecules based on the tetrahedral carbon atom that are still waiting to be made.

INTERVIEW: Keith McKennon cont.

KEITH MC KENNON (SYNC):

Right now, today, is the most exciting time that I've ever seen for chemistry and for the chemical industry. I think we have more opportunities, more exciting horizons, more contributions to make to humankind, and more capability to make those contributions than at any time in the thirty years or so that I've been part of this business, and I'm really looking forward to see how all that turns out.

Credits, Closing Montage, Closing Music

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